TM-(L)-734/035/00

TECHNICAL MEMORANDUM

(TM Series)

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Computer Operating Instructions for the Simulated Telemetry Data Generation Program (STSTLM)

Milestone 7

by

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22 March 1963

Approved

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TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	2
	1.1 Purpose	2
	1.2 Operational Description	2
2.0	ON-LINE PRINTOUTS	3
	2.1 Comment Printouts	3
	2.2 Error Printouts	4
3.0	INPUT	5
	3.1 Input Card Format	6
	3.1.1 "GENERATE" and "END" Cards	9
4.0	OUTPUT	10
5.0	METHOD	11
6.0	SUBROUTINES REQUIRED	16
7.0	RESTRICTIONS	16

IDENTIFICATION

TITLE: Computer Operating Instructions for the Simulated Telemetry Data Generation Program (STSTLM)

PROGRAMMED: 4 March 1963

J. Ng, System Development Corporation

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J. Ng, System Development Corporation

1.0 INTRODUCTION

1.1 Purpose

The Simulated Telemetry Data Generation Program (STSTLM) has been designed to generate a simulation tape (TLM-tape) containing input data for the TLM computer at the Tracking Station. In addition, the STSTLM program will also generate the System Time Code Word (STCW) and the Input Control Word in exactly the same format as they are normally input to the TLM Computer. As real time input, the simulated FM/FM telemetry data will be generated in record blocks. Each record will contain five frames of synchronized data normally input to the TLM Computer from the Telemetry Data Processor (TDP) each second. Each frame will have the appropriate frame sync bit set. Preceding each "data" record, there will be a "Time and Control" record, which contains the STCW word and the Input Control word. In the case of the Postpass Playback Mode, the format on the tape will be exactly the same as the Philco TLM-Computer History Tape.

1.2 Operational Description

The STSTLM program will be an integral part of the ASUM Master Tape. The program can be operated by request card in a manner similar to any other function of MTCII. However, the *STSTLM request card must be followed by the STSTLM control and data request cards (see Section 3.1). These cards are read by the STSTLM program.

Upon entrance to the STSTLM program, data request cards will be read in and stored. Then the program will perform legality checks on the input parameters and convert them to binary format. On-line error printouts are provided if sufficient information is not provided, or if errors are found on the input cards. After all the input parameters are checked and converted, the program will continue on to perform an initialization function and set up a calling sequence table (PARTBL). Each item in the PARTBL Table contains information pertaining to one analog input channel. Using the PARTBL as a reference, simulated telemetry data will be generated for one second of time.

If the simulation tape is to be used for a "real time" run, the data will be recorded in a "5-frame" record for each second, with a "Time and Control" record preceding each "data" record. If the tape is to be used for a "Postpass" run, the "Time and Control" record will be packed in the first and second words (160-A) of the "data" record. The total number of "data" records generated will be equal to the pass time-duration specified in seconds on the input cards.

2.0 ON-LINE PRINTOUTS

Two types of on-line printouts are provided. The first type is a "comment" on-line printout, which is recoverable. The second type is an "error" on-line printout, which is also recoverable if corrected.

2.1 Comment Printouts

1. Printout of input parameters prior to generation of data for input validation. This message on the printer will read as follows:

MODE NUMBER	PATCHBOARD IDENT	SYSTEM START TIME	PASS DURATION	WORDS PER FRAME	TYPE OF OPERATION
XXXX*	XXXX	XXXX	XXXX	XXXX	XXXX

ANALOG CHAN. NUMBER	FUNCTION IDENT	FIRST WORD ADDRESS	SAMPLE CONSTANT	NOISE ERROR OPTION
XXXX	XXXX	XXXX*	XXXX	XXXX
:	:	:	:	:
XXXX	XXXX	XXXX	XXXX	XXXX

*where XXXX are input parameters from the Input Cards.

2. The simulated data tape has been prepared. The message on the printer will read as follows:

   A SIMULATED TELEMETRY DATA TAPE HAS BEEN PREPARED ON LOGICAL UNIT 5. CHANGE TAPE.....THEN HIT RUN.....

3. When the simulation tape has reached an "end of tape" mark. The message on the printer will read as follows:

   THE TAPE SELECTED HAS REACHED THE END OF TAPE MARKER. TO CONTINUE, CHANGE TAPE AND HIT RUN.....

2.2 Error Printouts

If an error is found on the input cards, or when sufficient information is not provided, the following on-line printouts will occur and the program will stop. If the error is corrected, the *STSTLM function card should be left out prior to restart. Upon recovery, the program will restart from the beginning.

1. If the *STSTLM function request card is not followed by a "TLMPAR" card or "GENERATE" card or "END" card, then the program will stop with the following printout:

   FUNCTION CARD CANNOT BE INTERPRETED. PLEASE CORRECT CARD AND HIT RUN TO RESTART CYCLE.....

2. If the first card following the *STSTLM card is not a "TLMPAR" card, the program will stop with the following printout:

   INPUT CARD IS PLACED OUT OF SEQUENCE. THE FIRST CARD MUST BE A TLMPAR CARD. CORRECT CARD, HIT RUN.

3. If the first card following the *STSTLM card is a follower card (plus sign in the first column), the program will stop with the following printout:

THE FIRST CARD IS NOT TLMPAR CARD. PLEASE CORRECT.
HIT RUN TO RESTART THE CYCLE.....

4. If the type of simulation tape is not specified (real or post), the program will stop with the following printout:

   THE TYPE OF SIMTAPE REQUIRED IS NOT SPECIFIED. PLEASE PUNCH ON COL. 37-40 THEN HIT RUN TO RESTART.

5. If there is a mispunch on one of the parameters, the program will stop with the following printout:

   THE PARAMETER PUNCHED ON THE INPUT CARD CANNOT BE CONVERTED. CHECK AND CORRECT THEN HIT RUN.

6. If the STSTLM program cannot read cards from the card-reader, the program will stop with the following printout:

   CARD READER IS NOT READY. PLEASE CHECK EQUIPMENT THEN PLACE DECK IN READER, HIT RUN TO RESTART.

3.0 INPUT

Several input parameters in addition to an *STSTLM function card are necessary for the STSTLM program to generate realistic FM/FM telemetry data. These parameters will define the telemetry mode of operation and the initial system time. These parameters can be outlined as follows:

1. General Input for each Mode (first card)

   a. Mode Number (for Identification)
   b. Patchboard I.D. (for Identification)
   c. System start time (in seconds)
   d. Number of words per frame
   e. Duration of the pass (in seconds)
   f. Type of operation (Real Time or Postpass Playback Mode)

2. Input Parameters for each TLM measurement* (follower cards)

   a. Analog Channel I.D. number (for correlation)

   b. The function this point will represent when plotted against time (see Section 5.0)

   c. First word address of each measurement

   d. Sample Constant within each frame

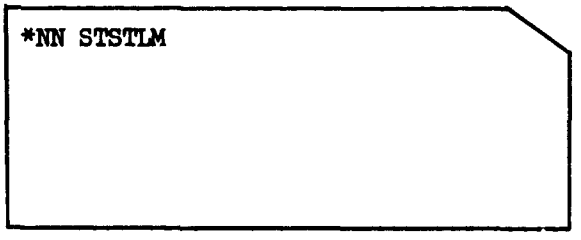
   e. The number of times each point will appear within one frame (frequency per frame)

   f. Optional noise error to be added on to each measurement.

3.1 Input Card Format

The input parameters, previously described, are input to the STSTLM program via punched cards. The first card must be a MTCII function request card (*STSTLM), followed by a function identification card, containing general input information for each mode, followed by input parameter cards describing each telemetry measurement for the selected mode.

1. MTCII Function Request Card



where NN = 13, if on-line storage analysis is desired.

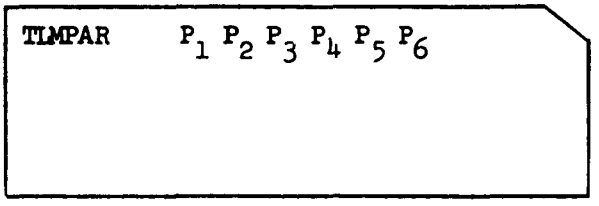
*The six parameters are repeated for each additional TLM measurement, but not to exceed 64 times.

The above card is read by MTCII, and the STSTLM program is read into the 1604 computer from the master tape. The calling sequence generated by the MTCII function is as follows:

```
L       NOP
        RTJ     STSTLM
L+1     SLJ       A
```

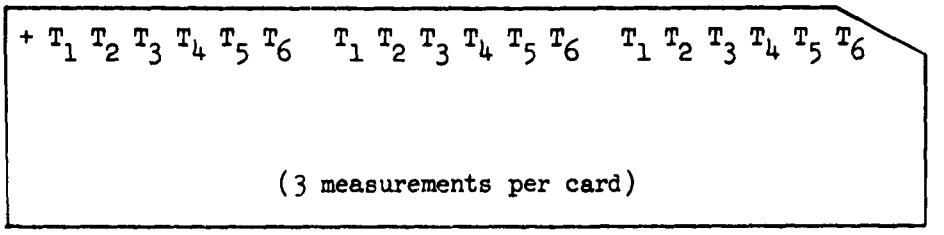
where A is the return address of MTCII when the STSTLM program has been executed.

2. Function Identification Card



Columns	Content	Description
1-6	TIMPAR	Function identification
9-12	P_1	Mode number (octal), right justified
14-16	P_2	Patchboard Ident (dec.), right justified
18-23	P_3	System Start Time (seconds in dec.), right justified
26-31	P_4	Duration of pass (seconds in dec.), right justified
33-35	P_5	Number of words per frame (dec.), right justified
37-40	P_6	Type of operation (alphanumeric)
		If real time operation = REAL
		If post pass operation = POST

2. Input Parameter Cards (a "Plus" sign in Column 1)



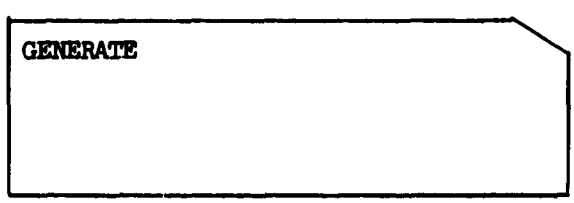
Columns	Content	Description
2-3, 26-37, 50-51	T_1	Function identification for each measurement. The last column of this field specifies the data generation module and the dec. number preceding (0-9) specifies one of the ten variations.
		a) Step Function: T_1 = iS where i=0, 1,.....9
		b) Steady State : T_1 = iL where i=0, 1,.....9
		c) Dynamic : T_1 = iW where i=0, 1,.....9 (See Section 5 to select the appropriate i.)
		d) Continuous Channel with increasing frequency: T_1 = OC
		d) Variable Period Sawtooth: T_1 = OA
5-8, 29-32, 53-56	T_2	First Word Address (0-799), right justified. This is the relative position of the first appearance of each measurement within one frame.
9-11, 33-35, 57-59	T_3	Sample constant (1-799), right justified. This number is added onto the first word address to locate the next sample of this measurement.
13-15, 37-39, 61-63	T_4	Frequency per frame (1-799), right justified. This parameter specifies the number of samples available for each measurement within one frame.

Columns	Content	Description
17-18, 41-42, 65-66	T_5	Analog channel number (1-64), right justified. This parameter is used for correlation for each telemetry measurement.
20, 44, 68	T_6	Noise error option (1-8), or blank. The parameter on this column specifies the number of least significant bits of this measurement that will contain noise error.

3.1.1 "GENERATE" and "END" Cards

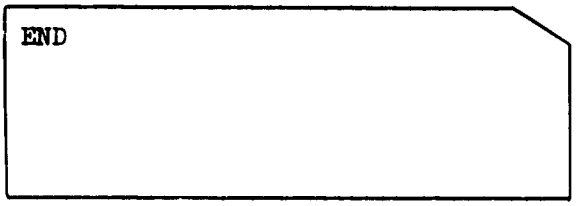
Following the last Input Parameter Card, a "GENERATE" Card must be present. This card will start the STSTLM program to prepare one simulation tape. Following this card, another tape can be prepared for another mode. The program will stop at the end of each generation of a simulation tape. If the next card following the "GENERATE" card is an "End" card, the program will return control to MTCII. The formats of the "GENERATE" and "End" cards are illustrated as follows:

1. "GENERATE" Card



Columns	Content	Description
1-8	GENERATE	To start the generation of telemetry data. The program will write on Tape Unit 5.

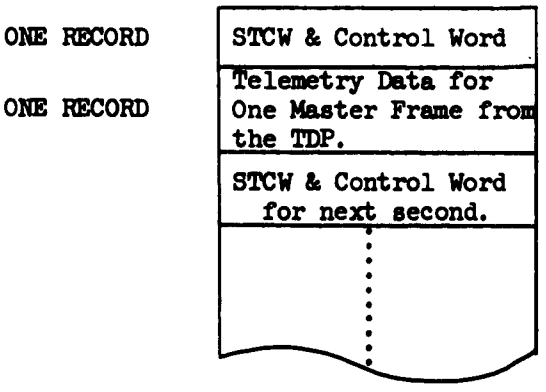
2. "End" Card



Columns	Content	Description
1-3	END	When the STSTLM program reads this card, control is returned to MTCII.

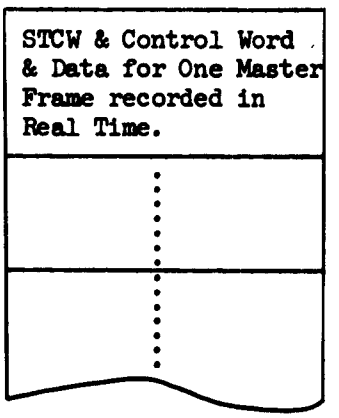
4.0 OUTPUT

Two types of output on magnetic tape are provided by the STSTLM program. One type will be used to operate the TLM Computer in a real time mode. The other will be used for a Postpass Playback Mode. These two tapes differ only in format. The two formats are illustrated as follows:



Real Time Tape

INPUT TO TLM COMPUTER FOR ONE SECOND.



Postpass Playback Tape

5.0 METHOD

There are five main subroutines in STSTLM that will generate raw telemetry data (8-bits). When these data points are plotted against time, they will represent five basic functions: Step, Steady State, Dynamic, Sine Wave for a continous channel with increasing frequency, and Variable Period Sawtooth functions. Associated with these subroutines, there is a noise error contamination routine which is used to contaminate the least significant bits of the output from the data generation subroutines.

Since the function patterns represented by the Step, Steady State, and Dynamic functions vary from channel to channel and from vehicle to vehicle, additional input parameters become necessary in order to simulate vehicle-specific telemetry measurements. In many cases, the function patterns for each analog channel are hard to predict prior to an actual flight. Consequently, the STSTLM program has provided ten fixed patterns for each of the three basic functions (Step, Steady State, and Dynamic) for general purpose checkout capabilities. However, if the patterns can be predicted, the user can modify the appropriate items in the parameter tables so that the patterns generated, using these new parameters, can be represented as the actual telemetry measurement from a specific channel and a specific vehicle.

1. Step Function

The equation used to generate a telemetry measurement (y) which can be represented as a Step Function is:

$$y = b_i + (-1)^{p} \Delta b_i$$ where p_i increases by 1 for each k_i seconds of time.

The variables are: b, Δb, and k. The ten variable patterns are presented in the following table.

Step Function

i	b_i	Δb_i	K_i	P_i
0	125	8	10	0
1	135	10	20	0
2	145	12	30	0
3	155	14	40	0
4	165	16	50	0
5	125	18	60	1
6	135	20	70	1
7	145	22	80	1
8	155	24	90	1
9	165	26	100	1

where i = pattern variable specification for T_1 (1S).

2. Steady State

The equation used to generate a telemetry measurement (y) which can be represented as a steady state function is:

$$y = a_i t + b_i - (p_i a_i k_i)$$ where p_i increases by 1 for $y \geq 248$ or $y \leq 8$ as t increases (t=time).

The variables are: a_i, b_i, k_i, $X\ (max/min)_i$. The ten variable patterns are presented in the following table.

Steady State

i	a_i	b_i	$X(min/max)_i$	k_i	p_i
0	2	8	248 max	120 sec.	0
1	4	8	248 max	60 sec.	0
2	8	8	248 max	30 sec.	0
3	16	8	248 max	15 sec.	0
4	32	8	248 max	7 sec.	0
5	- 2	248	8 min	120 sec.	0
6	- 4	248	8 min	60 sec.	0
7	- 8	248	8 min	30 sec.	0
8	-16	248	8 min	15 sec.	0
9	-32	248	8 min	7 sec.	0

where i = pattern variable specification for T_1 (iL).

3. Dynamic

The equation used to generate a telemetry measurement (y) which can be represented as a Dynamic Function is:

$$y = a_i \sin (Kt) + b_i$$ where K is a modifier, such that $(Kt) \leq 2\pi$; and $0 < y \leq 248$.

The variables are: a_i, b_i, $X\ (max)_i$. The ten variable patterns are presented in the following table.

Dynamic Function

i	a_i	b_i	$X(max)_i$	K
0	118	128	248	1 or $1/n\pi$
1	108	128	248	
2	98	128	248	
3	88	128	248	
4	78	128	248	
5	68	128	248	
6	58	128	248	
7	48	128	248	
8	38	128	248	
9	28	128	248	

where i = pattern variable specification for T_1 (1W).

4. Continuous Channel

The equation used to generate a sample of a telemetry measurement (y) which has an increasing frequency each second can be represented as follows:

$$y = a \sin (2\pi x f_{i/s}) + b \qquad (f_{i+1} = f_i + \Delta f \text{ each sec.})$$

where
- a = bias value
- f_i = current frequency
- s = sampling rate
- b = center frequency
- Δf = rate of increase of frequency
- x = 0,1,2,3,.....S-1 (where X is reset to zero at the beginning of each second)

In the present program, only one set of prestored values is used:

- a = 102 (2 volts)
- f_o = 400 cps (initial frequency)
- s = 4KC (sampling rate)
- b = 128 (2.5 volts)
- Δf = 0.1 cps

The program will generate 4000 samples per second. At the end of each second, the frequency will be increased by 0.1 cps.

5. Variable Period Sawtooth

The equation used to generate a sample of a telemetry measurement (y), which has a varying period with a constant amplitude, can be represented as follows:

$$y = a(.1x) + b$$

where x increases by 1 per sample.
$1 \leq x \leq n$ for each period p
$n = Kp$
$p = 2^1, 2^2, \ldots 2^7$, then repeat.
K = number of samples per sec.
b = bias value

The slope $a = 2^7, 2^6, \ldots .2^1$ then repeats, and the output is limited $0 < y \leq 377_8$. In the present program, one set of prestored values is used:

$a = 2^7$ for a period of 2 seconds, then the period changes to 2^2 seconds with $a = 2^6$ and so on, until $a = 2$ and period is 2^7, then the above is repeated.

K = 1.0
b = 0

6. Noise Error

The method of contaminating the raw telemetry data with noise error is by substituting the least significant bits of each sample with random bits from a random number generator. The number of bits (n) to be contaminated is input to the STSTLM program by the user.

6.0 SUBROUTINES REQUIRED

SIMBLANK	INPUT	OUTPUT	OUTERR
DECOCT	FLOAT	FIX	
SIN	UNPACK	FLOATBIN	

7.0 RESTRICTIONS

1. Telemetry type is restricted to FM/FM only.
2. Algorithms to be applied to the data are restricted to 1-5, 7 and 10.
3. The number of frames is five per second.
4. Only Step, Steady State, Dynamic, Sine Wave with increasing frequency, and Varying Period Sawtooth functions are generated.
5. The first word of each frame will always contain a frame sync bit. Therefore, no alarms will be generated by the PTLMS program for the case of loss of S&D sync.
6. All decommutators will be in sync.
7. Logical Tape Unit 5 will be used as an output tape by the STSTLM program.

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System Development Corporation,
Santa Monica, California
COMPUTER OPERATING INSTRUCTIONS FOR
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Satellite Networks.

Reports that the Simulated Telemetry
Data Generation Program (STSTLM) has
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